Intl. J. of Technology Assessment in Health Care, 1987, 3, 193–198. Printed in the United States of America.

PROLOGUE

The Transformation of Hospitals through Technology

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BACKGROUND

Throughout the centuries, hospitals have developed according to the needs of society. The infirmaries and quarantine hospitals of the fourteenth and fifteenth centuries were gradually transformed first into general hospitals and then into highly specialized contemporary hospital systems. Their structure was adapted to the progress of medical science, but only in the course of the last two or three decades has technology become the central driving force in hospital structure and organization.

The technical revolution of our society has so transformed the hospital that public opinion seems often to be fascinated more by its technical aspects than by the medical aspects of its functioning. It is asserted by many statisticians that hospitals account for half of the total expenditure for health in industrialized countries and that the increasing costs of hospitals are in large part due to the implementation of new technologies.

The reason for discussing the organization and the use of technology in today's hospitals is the recognition that in a changing environment, with an increasing segment of the population in the Northern Hemisphere growing older, and in the absence of a concomitant economic growth, our health care policies have to be critically evaluated. The modernization of hospitals will certainly continue, but it is doubtful whether, in the long run, this can be done at the expense of other equally important health programs, such as health promotion, disease prevention, and rehabilitation. Painful choices cannot be avoided and they will have to be based on assessment of the progress brought about by technology in the costliest sector of health care, the hospital.

In the twentieth century, the implementation of technology in hospitals went through different phases. The phase of enthusiasm came about when technology

was introduced on a larger scale into hospitals. It started with the introduction of x-ray equipment as diagnostic and therapeutic tools (1910–1920), with the widespread use of the cardiogram (1930s), and the use of intubation anaesthesia (1940s).

A phase of optimism after the World War II brought about a series of spectacular innovations: hip-replacement, artificial pacemakers and other artificial organs, intensive and specialized cardiac-care units, cardiac surgery, renal dialysis, and renal transplants were some of the landmarks of progress. Fresh funds were committed to cancer research centers in the belief that important advances were within reach and that only money was needed to achieve them. Imaging by computerized tomography and nuclear magnetic scanning added new possibilities to the diagnostic armamentarium. Funds were available and no cost was too great in the eternal task of curing sickness and postponing death. Despite repeated criticism from health economists, health service analysts, representatives of sick funds, workers' unions, and other interested parties, costs eventually were always met. As long as professional ethics and human justice demanded that for every person the best health care that could possibly be provided (which often proved to be the most expensive) be available, only a desperado in the health scene would deny his right to get "the best," given the current state of medical knowledge.

Today, the situation has changed. The economic crisis of the early 1970s foretold the phase of concern about technological progress in medicine. In little more than a decade, the public at large, health politicians, even the medical profession, began to realize that cutting medical costs was not just a matter of budgeting and reimbursement, but that more fundamental elements have to be considered when health is at stake. More and more people began to realize that the principle of "cost being no object where human life is at stake" offers no ultimate ethical guidance, for it invariably must result in inequity as resources become scarce.

A CRITICAL APPRAISAL OF THE PRESENT SITUATION

The advances in technology since the introduction of the microcomputer have had numerous consequences, not merely in physician and nursing services, but throughout the health care scene. The development of technology-based allied health professions means that only about 50% of health manpower in modern hospitals is directly involved in patient care. The other half is involved in supportive activities. Further, the use of modern laboratory methods in the hospital has increased the number of personnel indirectly involved in hospital services, thereby fragmenting hospital care into autonomous areas of responsibility, which results in increased services in number and type per hospital day. Technology has forced more discussion of ethical issues such as the right to live, to be treated, and to die; defensive medicine has resulted in a move toward providing more preventive measures rather than less because of the individual demands by patients and doctors. Finally, the interest of the hospital administration in new technology has grown, and rate-regulation mechanisms allowing for additional charges for added technologies has led to the pricing of new services at higher rates than the older technology patterns.

The higher the profits expected from each innovation, the more quickly a new technology is adopted. In the presence of extensive third-party coverage for costs

of medical care, there is no practical limit to the number of medical acts which, if available, can be performed ("diagnostic overkill"). Because of the high level of third-party coverage for hospital care, there is no incentive for hospitals to reduce investments in new equipment and to compete on the basis of price. In order to stay in business, structures and services must be of high standard and the most advanced modalities must be offered.

The organization and use of technology clearly reflects the dilemma of the modern hospital, namely, to treat people, to achieve scientific progress, and to survive under budget constraints. Cost-containment policies (e.g., DRG) influence the introduction of new technology in public hospitals. But it is quite evident that recommendations are more precise in the fields of finance and manpower, and less so in questions of medical service priorities or in the quality of services rendered. Therefore, medical technologies will, in the foreseeable future, continue to be applied, even before their real effectiveness has been proven in practice, or their marginal benefit can be questioned.

THE NEED FOR TECHNOLOGY ASSESSMENT IN HOSPITALS

In the industrialized world today, we foresee a growth rate in technical investments in medicine of close to 15%, which corresponds to an increase on the order of magnitude during the rest of this century. Thus, technology assessment should become an integral part of hospital services research. This is especially important because of the rapid transformation of hospitals through the implementation of new technologies. A systematic evaluation of outcome has to go beyond the scientific analysis of the individual process with the instruments of medical and economic science, but has to include the appraisal of individual and social values as well. This means that we have to recognize the patient's point of view to a greater extent than we did in the past. In a complex social system such as a hospital, it is necessary but rarely sufficient to monitor economic expenditure in order to evaluate the *quality of services*. In addition, social and medical criteria are needed, as are attempted in technology assessment.[1]

Evaluation should also consider the individual social effects of a given technology in cases where the patients concerned and other parties involved have no interest in common. The "private" calculation and planning of vested interest groups (insurance agencies, HMOs, etc.) might differ from individual value judgments.

To be beneficial and useful to the policymaker, evaluation of new technologies has to reflect the future potential of a given technology in realistic terms that include the expression of the degree of uncertainty of the scenarios applied.

The point is that technology assessment must be interdisciplinary. In a recent review of the contribution of social sciences and health services research to public policy, Bice states that "although the field draws upon knowledge from biomedical and epidemiological research, and upon experience in clinical medicine and health care administration, its theoretical and methodological bases are drawn largely from the social sciences" (1).

TECHNOLOGY ASSESSMENT AND HOSPITAL MANAGEMENT

Technology assessment and planning form an iterative sequence of events in the course of implementation and evaluation of new technologies in hospitals. They are elements in the network of a highly complex and dynamic system that is called a hospital. Economic analysis is only one facet of the process, clinical quality assurance is another. In the end, both aspects cannot be separated from each other. In a world where the growth of technology is, in general, closely related to the economic growth (or production of monetary resources), the development and implementation of medical technology has to be evaluated in relation to returns on investment both in human benefit and in economic values (e.g., in terms of improved health and monetary savings, compared to an alternative).

Modern hospital management can be separated into four integral steps or pathways which are interrelated: (1) the definition of goals of the hospital as a whole, of a department, or an outpatient clinic; (2) the determination on the available structure; (3) the monitoring of the processes involved; and (4) the evaluation of outcome. These four elements should also be considered as an integral part of technology assessment. In addition, programs aimed at this type of assessment should fulfill the following requirements:

Reflect Reality. Follow the complex pathways of interrelated events related to the use of a given technology, feedback and feedforward effects, exceptions to the rule, etc.

Evaluate Effectiveness. The concept of effectiveness is used to establish the extent to which a specific intervention is made available to all those in a defined population who might be expected to benefit from it. The design of projects for purposes of evaluating "effectiveness" often uses randomized groups or retrospective samples of the population with or without a specific disease. Studies might focus on equipment, institutions such as hospitals, or private practice. Crossover designs, time series before and after studies, etc., may be employed.

In the course of the centuries, "efficacy" and "effectiveness" have always been estimated in an intuitive sense. A good technology was one that "worked" and did not cause undue harm. Major portions of procedures in use in medicine today have been evaluated by this intuitive method. Clinical trials under controlled conditions or controlled studies on randomly selected groups of patients are an exception. The most critical and central defect in many clinical studies is possibly the lack of control experience.

Measure Efficiency. Because of the lack of a direct and explicit relationship between the sharp increase of costs in health services, the expanded use of medical technologies, and improved health, questions have been raised about the efficiency of our health care delivery systems. Measures of efficiency reflect financial inputs or human inputs in terms of working hours in relation to the product (a laboratory result, a head scan, or a performed dialysis) as an output, regardless of its contribution to outcome in terms of improved health and regardless of optimal mix of resources.

Evaluate Results in Social Terms. One definition describes health services research (HSR) as "concerned with studying relationships between consumers

and providers as they affect and are affected by health care organizations, technology, financing, and payment systems'' (3). Unlike biomedical research, HSR in the past has drawn primarily on the social sciences and not on the clinical and technical sciences, although in-depth knowledge in these fields would be essential. More important perhaps, HSR depends on the ability of its investigators to translate findings into action and to initiate innovations.

HSR resulted from a growing recognition that substantial improvement in the efficiency and effectiveness of health services is most likely to be achieved by expanding our knowledge of the behavior of the actors on the scene and through testing and evaluating new approaches to producing, financing, and delivering health services. In general, problems which affect the allocation of resources used by a large segment of the population or which command legislative interest would seem to be obvious candidates for research. Yet there is no widely accepted scheme for weighing and ordering the myriad of health care problems in terms of relative importance.

SUMMARY

The highly disparate studies on access, cost, use, and quality need to be put together. The interdependencies among these factors and the impact of modern high technology need to be considered in order to make more realistic contributions to health policy.

In particular, our experience in measuring effectiveness and costs of procedures, such as diagnostic scanning, automated laboratory tests, advanced care systems, and sophisticated treatments, should be developed in order to improve the contemporary state of knowledge and test assumptions on which current programs and policies are based. More important, however, special approaches for assessing systems effects of technical, procedural, organizational or political changes, and financial regulations, need to be developed.

Therefore, evaluation remains an essential element in health services research. It requires monitoring of achievements as compared with previously established targets of performance and objectives. Attention must be given to complexity, taking into account not only the economic problem of resource allocation in the face of increasing political pressures, but also those more intangible values which cannot be expressed in simple logarithms, such as hope, expectations, speculations, and fears, which certainly influence our choices and decisions in health matters and explain or modify, to a certain extent, systems behavior.

From the very beginning, research should be interdisciplinary and interprofessional. Methods should be adopted which allow ''micro-level'' or clinical evaluation as well as systems evaluation. ''Correct'' attribution of effect to cause requires not only a careful study design but also a careful selection of those variables necessary to build models that can be tested in scenarios.

Generalizing of results must be done with extreme caution. Efficacy studies or results of cost–benefit analyses cannot easily be generalized as they are usually not conducted in such an institutional and human context which would permit this.

The dilemma is increased by new developments, especially by new technologies. Decision makers want evaluative results before the progress is adopted and

yet more often evaluation can proceed only when new procedures and ways of patient management are already adopted.

One must agree to live with a constant degree of uncertainty and variability. In order to stimulate progress in the right direction, the evaluation should from the beginning work in close cooperation with the policy-making body. This is important not only to assure the collection of pertinent and sensitive data, but also to ensure comprehensive interpretation of the results and to enable the policymaker to participate in the debate and in the process of continuous adjustment of the processes directed toward future objectives in the most appropriate way.

NOTE

[1] "*Technology assessment* is a class of policy studies which systematically examines the effect on society that may occur when a technology is introduced, established or modified, with special emphasis on those consequences that are unintentional, indirect or delayed . . . comprehensive impact or assessment studies which attempt in some sense to embrace everything that is important with regard to technology." (2)

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